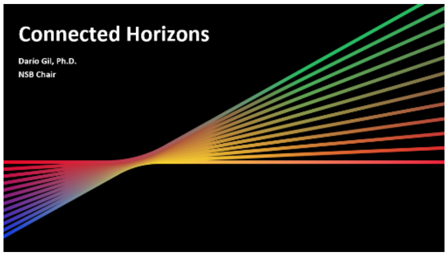
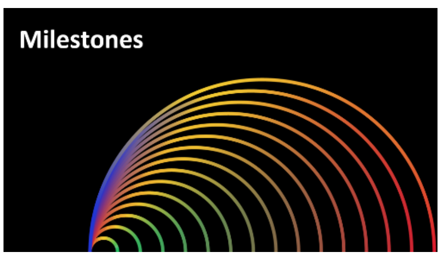
NSB Chair Darío Gil Address

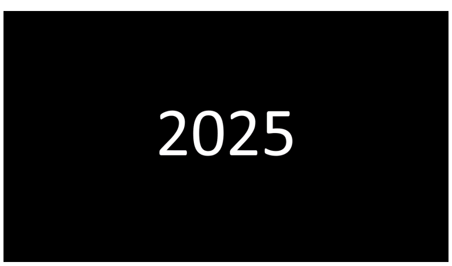
Connected Horizons
New Opportunities in a Changed Landscape
July 2024



I'd like to take a little more time than usual to share my perspective on the unfolding of events over time as it relates to the science and technology landscape, where we are today and highlight the opportunities to embrace and respond to the changes to secure US S&T leadership for the next 75 years and to deliver the benefits of scientific and technological progress to all Americans.



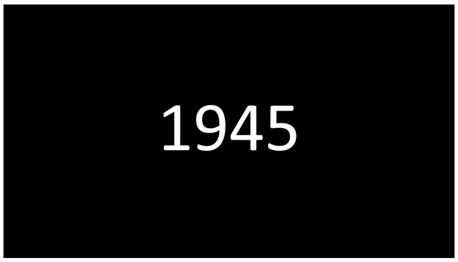
I'll begin with significant trends that have been altering the landscape for the past several decades.



It's amazing but we're already nearly a quarter of the way into the 21st century – and what a transformative time this has been! And next year will be the 75th anniversary of NSF.

In 2020, the National Science Board published *Vision 2030*, a 10-year roadmap for U.S. science & technology – and we're already halfway through that decade. I think we can all agree that the world has changed far more than we could have imagined in the last five years.

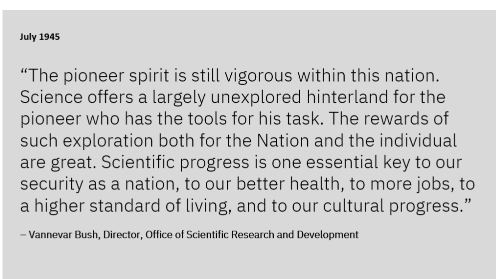
So, this is a good moment to take stock. Where have we been? Where we are now? Where do we want to go?



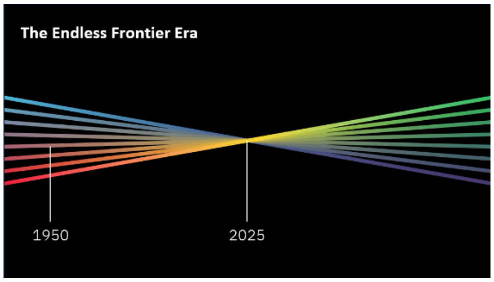
Let's start by going back to 1945.

World War II marked the waning of European S&T dominance – and, in part due to the U.S. welcoming refugee scientists, the start of U.S. S&T leadership.

And as the war entered its waning months in 1945, the first steps toward creating a new set of S&T institutions were already taking place, including my own institution, IBM Research, which was born in March of that year.

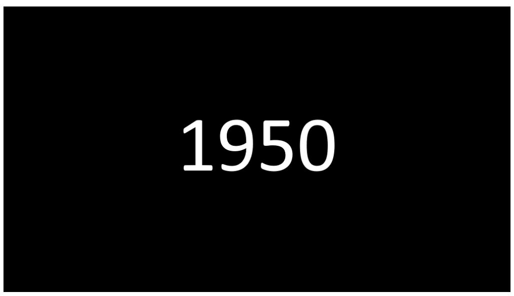


The same year, in July of 1945, Vannevar Bush, the head of the wartime Office of Science and Technology Research, delivered his famous report to President Truman, *Science - The Endless Frontier*. In there, he famously proposed the creation of a "National Research Foundation" to leverage the collaboration between government, university, and industry in science and technology that was so successful in the war effort and to extend it for a new era of peace. He expressed it nicely, that "scientific progress is one essential key to our security as a nation, to our better health, to more jobs, to a higher standard of living, and to our cultural progress."



With this, we had the start of a wave of building S&T institutions– what I'll call the "Endless Frontier era."

It emerged from the belief that science was more than just a "hinterland" for exploration. That it was a fundamental tool for ensuring the nation's security, welfare, health, and prosperity.



President Truman officially signed the National Science Foundation Act in 1950. NSF was a new institutional model. While earlier federal government S&T investments and institutions had focused on specific topics and in specific areas, NSF supports fundamental research across all non-medical fields.

I know we're all proud of the fantastic discoveries and accomplishments that NSF has made possible over the past 75 years, together with our stakeholders and research community partners.

Look, the truth is that over the Endless Frontier era we have developed our own mythologies about science and innovation – about how it works, about who does science, about who supports what components of the work.

We have a mental model of science that starts with government funding of basic research at colleges and universities and transitions into industry for the final stages of development – even though there have always been feedback loops, and funding loops, between and across sectors.

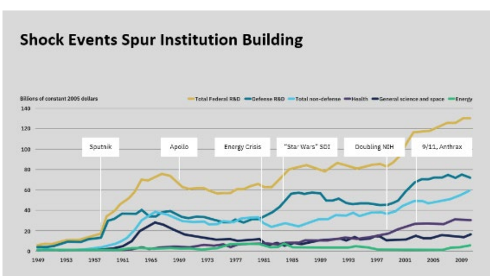
And we tell a story about Bush's *Science – the Endless Frontier* that suggests that it was embraced more readily, consistently, and fully than it actually was.

Congress debated for 5 years Bush's vision of a National Research Foundation with total independence and a broad scope. Meanwhile, the world was moving *fast*.

NIH added its extramural grant program and the Public Health Service.

And the Navy created the Office of Naval Research and developed partnerships with universities.

By the time NSF was finally established, its remit and independence were very different – and greatly diminished – relative to Bush's vision in *Science – the Endless Frontier*.



So rather than a tale of broad exploration of fundamental science across all fields spearheaded by an independent Foundation of the type Bush envisioned, the real federal S&T story over the past 75 years is largely mission-driven, with shock events driving institution-building and R&D budgets.

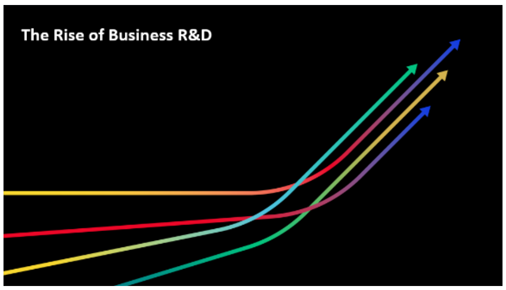
The launch of Sputnik in 1957 led to a rise in defense R&D, the establishment of NASA and DARPA, and the passage of the National Defense Education Act to develop talent, particularly in STEM.

The energy crisis in the 1970s led to the creation of the Department of Energy.

The end of the Cold War and sequencing of the genome paved the way for doubling the NIH's budget in the 1990s, and with 9/11 and the anthrax scare, that doubling came to fruition.

And now, our reliance on global supply chains, particularly for silicon chips, brought some vulnerabilities that led to the CHIPS & Science Act of 2022.

But while the institutions Bush envisioned changed substantially, his arguments, and the wartime successes under the Office of Scientific Research and Development, ultimately led to a transformational change in our S&T ecosystem: the federal government took on a new role as a funder of basic research across all fields and we had the rise of partnerships between government and academia.

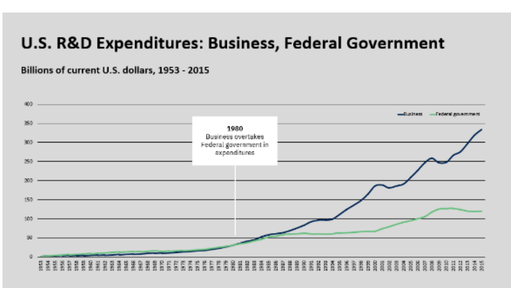


Private sector research and development was also a key part of the story.

In the early 20th Century, GE, DuPont, Kodak, and AT&T created corporate research laboratories. Other companies, including IBM, followed suit during the interwar years, and we started to see the growth of business R&D.

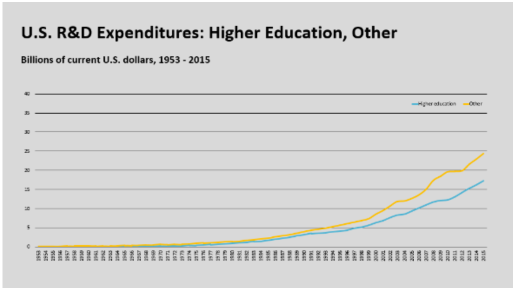
During the 1950s, federal funding augmented the investments that businesses were making in R&D, and in fact, federal funds were the largest source of support for R&D conducted by private business. The federal government spent large sums well into the 1960s supporting use-inspired basic research and development work in the private sector.

These labs were very successful in addressing technical challenges and yielding new products. They also made profound contributions to the natural sciences and computer science.



But after 1968, the federal government began to pull back its funding for business R&D, and the share of total R&D that was federally funded began to decline.

Business R&D remained strong. Then, in 1980, we reached a significant milestone in the evolution of post-war S&T: business investment overtook the federal government as the largest funder of R&D, returning to the pre-WWII pattern.



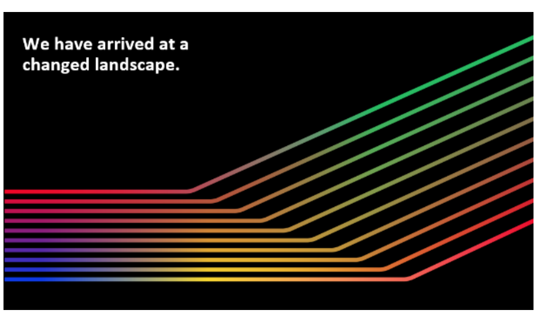
Academia's role begins in the latter half of the 19th century with establishment in the U.S. of the modern research university.

While the federal government has been the primary source of funding for academic research during the Endless Frontier era, in more recent years, funding of research by higher education itself has itself been on the rise.

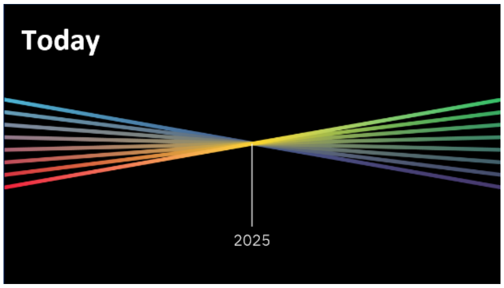
Private philanthropy also has a deep history in research and education. In the late 19th Century, philanthropy was a significant contributor to the establishment and endowments of many of our nation's leading research universities and prior to WWII, philanthropic entities like the Rockefeller Foundation played a significant role in US science funding.

Today, philanthropy is still a fairly small fraction of research funding overall, but Robert Conn, former President and COO of the Kavli Foundation, recently argued that we may be entering a second significant era of direct philanthropic funding of research. Whether this will pan out remains to be seen but it's a trend worth watching.

Later this morning we'll hear from S&E leaders from government, industry, philanthropy, and academia about how the R&D ecosystem has changed in each of these sectors over the last ten years and what we can do collectively to seize opportunities.



That brings us to today, and to a landscape that has evolved markedly from the world of Vannevar Bush.



In our new Board piece that we released earlier this week, we described the three key features that are foundational to our changed landscape.

First, business funding has risen dramatically, with an accelerating growth rate.

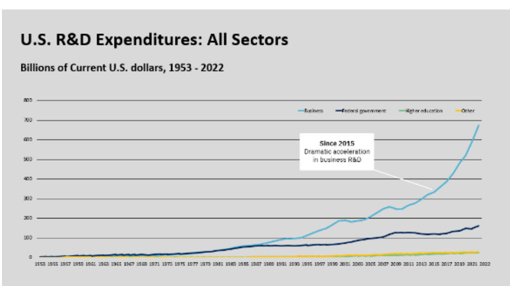
Second, U.S. leadership in S&E is eroding, in part due to China's rising investment in S&T.

And third, there is a rapid increase in the number of jobs that require a workforce with STEM skills.

At the same time, public trust in institutions continues to erode. This is a global phenomenon.

Science and scientists continue to enjoy high levels of trust relative to many other institutions, but science is not immune from this trend.

Now, let's explore the changed landscape, starting with U.S. funding for S&T.



Since 1980, business has funded the largest share of U.S. R&D, and in the last decade there has been a *dramatic* acceleration in the growth of business R&D. This is a clear change since the mid-20th century: business has shifted from being primarily a beneficiary of investment to being a driver in its own right.

Now, it's important to note that private sector R&D is very concentrated and clusters in a few key sectors like information technology and pharmaceuticals. In fact, software R&D *alone* has grown dramatically, from about a fifth of business funding in 2006 to over 40% in 2021.

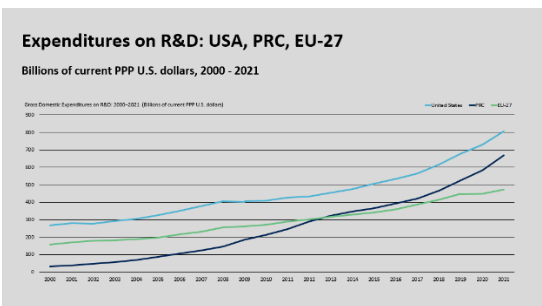
Though the lion's share of industry R&D funding goes to experimental development, the private sector also conducts fundamental research. I will give the example of my own institution.

In mathematics, IBM contributed algorithms and models that are used nearly everywhere, from matrix multiplication algorithms to universal hashing, Mandelbrot fractals, and the modern generic version of the fast Fourier transform.

And more recently, in quantum information sciences, IBM invented quantum teleportation, put the first quantum computer in the cloud for anyone to use, and brought the first fully integrated quantum computer to the world, to be deployed outside the confines of our labs.

We should celebrate the contribution of business R&D, which drove U.S. R&D to 3.5% of GDP in 2021. But we should also be clear that business R&D is not a *substitute* for federal R&D. The two are complementary.

The business sector has long relied on the federal government to make the crucial initial bets on new ideas across *all* scientific fields. Many of the S&T advances that underpin today's commercial technologies and industries are rooted in research conducted decades before practical applications were realized. Simply put, federal investment in fundamental research today enables the emerging industries of tomorrow.



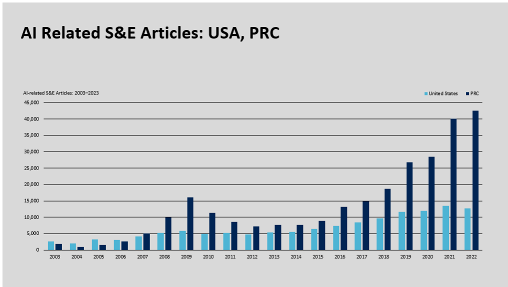
One consequence of the success of U.S. S&T over the last 75 years is that science and technology now has the same kind of economic and geopolitical importance as trade or military alliances. It is now a major playing field for economic and defense competition.

Which brings me to the second feature of the changed landscape: China is our biggest competitor, but it's also one of our biggest collaborators.

The rise of China's prominence in S&T began with sustained increased funding of R&D at levels that eclipsed those of the EU around a decade ago. Those investments are now bearing fruit.

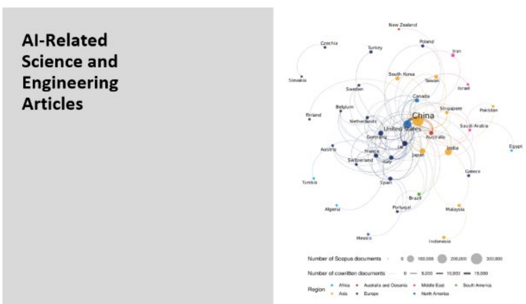
For the past decade, with each release of our *Science & Engineering Indicators* report, the National Science Board has sounded the alarm as the U.S.'s lead has eroded on more and more global S&E metrics.

China has now surpassed us in research publications, patents, in knowledge-and technology-intensive manufacturing and now for the first time, China is awarding more PhDs in S&E than the U.S.

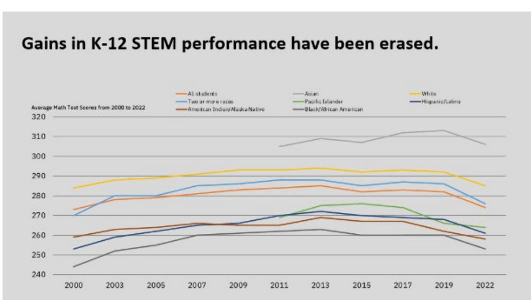


China is a formidable competitor in technology areas critical for national security, including AI, semiconductors, quantum computing, and biotechnology. And now patents more than the U.S., including in AI.

China's publication pace has also skyrocketed over the last decade. If we look at AI specifically, China's publication rate is *outpacing* the U.S.



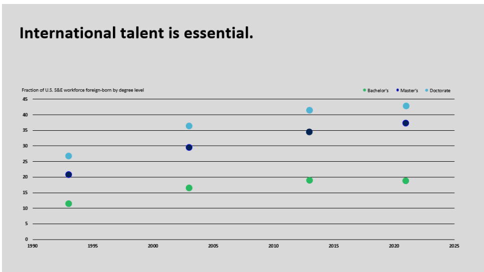
Of course, this is not a zero-sum story. As I said before, China is *also* our largest collaborator in published research, including in AI.



Finally, the third feature of the new landscape. At a moment when S&T is increasingly important to the nation *and* we have increasing competition with China, the U.S. is facing a STEM talent crisis.

Trained and talented people drive innovation by carrying promising ideas from the laboratory to the workplace. It's deeply worrying that we're failing to adequately educate and nurture our domestic students and workers.

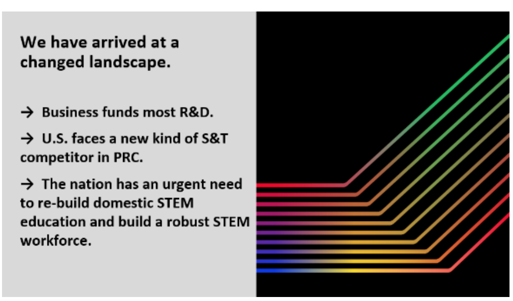
Among advanced economies, U.S. K-12 students have long been merely "middle of the pack" in STEM performance. But now, data from 2022 show that the little gains that U.S. students made in mathematics proficiency in the past 20 years were erased during the pandemic. These declines are the largest for individuals from race and ethnicity groups that are already marginalized in STEM – the "Missing Millions" – and for individuals from low socioeconomic status households.



Fortunately, the U.S. continues to be a beacon for talent from around the globe. The share of U.S. S&E doctorate-level workers who are foreign-born has grown from 27% in 1993 to 43% in 2021.

It's wonderful that we attract talent from across the globe. It's a key strength and source of vitality for our S&T ecosystem. But it's also a potential risk, because our dependency on that talent is also at an all-time high, particularly in critical and emerging technology fields. And we're failing to create sufficient mechanisms to retain the talent that wants to remain and work in the U.S.

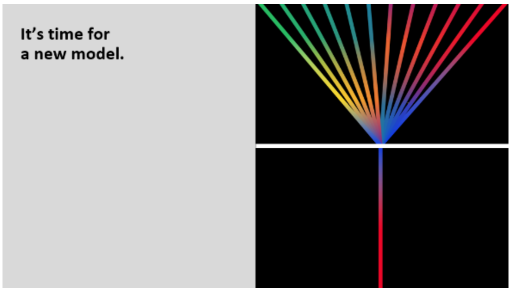
I know that none of us underestimates the scale of this problem. Improving and modernizing our highly decentralized education system is an enormous and complex task. Cross-sectoral collaboration will be necessary to rebuild domestic STEM education and build the robust STEM workforce that the U.S. will need to maintain leadership in a world driven by science and technology.



So now let's take a moment to pause and reflect.

The institutions built in the Endless Frontier era have radically changed the world, to the point where those institutions themselves need to adjust.

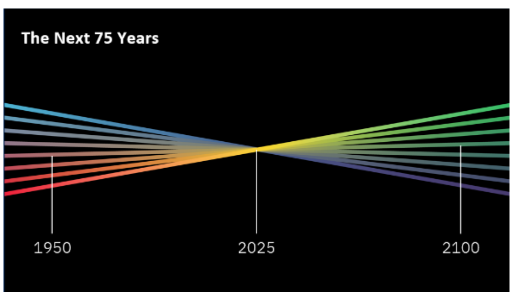
And so, now is the time to build for the *next* 75 years.



I believe that the time has come for new models, new approaches, and new institutions that embrace this changed landscape to secure US S&T leadership for the next 75 years and deliver the benefits of scientific and technological progress to all Americans.

We must recognize that today, and for the foreseeable future, science & technology is as integral to our national power, security, prosperity, and happiness as trade or military alliances.

To adapt to and seize the potential of the current landscape, we must optimize cross-sectoral collaboration to draw on the strengths of all parts of our S&T ecosystem.



I see this presentation as the start of a dialogue that I would like to invite you to join, starting now.

I'll put a few things on the table. I hope to start this conversation by asking good questions.

One clear implication of the current landscape is the elevated geopolitical importance of S&T.

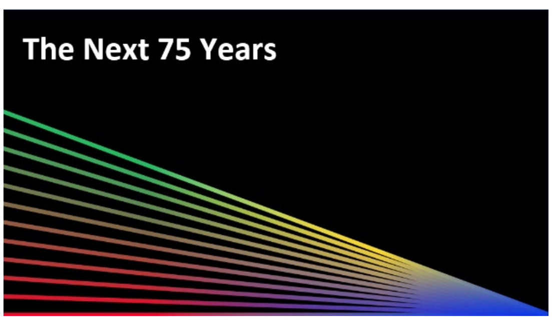
Science and technology are now indispensable pillars of our nation's hard and soft power, of our national security, and our economic prosperity. The success of the S&T endeavor both in the U.S. and globally has been such that science and technology are the new currency of power.

This is a new paradigm and it's a game-changer. It will affect what research we prioritize, who and how we pursue and fund it, how and with whom we collaborate, and the rules, ethics, and laws that govern the playing field. And it affects what it will take for the U.S. to be a global leader in S&T.

Not coincidentally, there are a lot of new restrictions, export controls, research security reporting requirements, and all that. It impacts our time and our conduct of research so as practitioners, we have to adapt to this new reality while working to ensure that the new models and policies are designed thoughtfully and fairly and preserve the openness of scientific inquiry that we know is essential to progress.

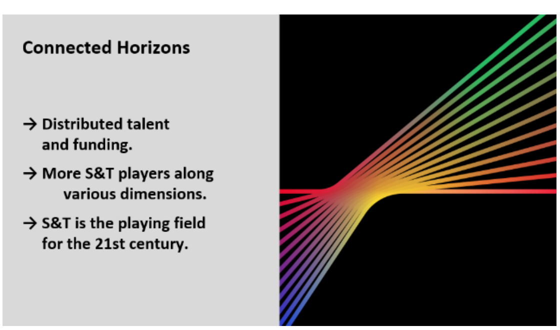
While our institutions race to perform cutting-edge research and technology development, we should also not lose sight of what Americans want and need from S&T to make their everyday lives better. And we should not assume that we know what "better" looks like.

As we develop and evolve institutions, we can design them to also prioritize direct engagement and responsiveness to the American public. Let's think now about how to build inclusive new models so we can avoid public distrust in science a few years from now.



So now it's time to look to the future – to the next 75 years.

[27 – Connected Horizons]

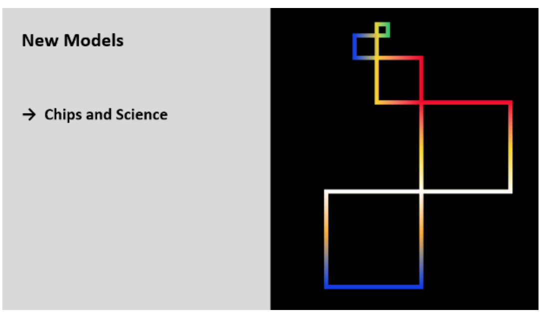


CHIPS is a necessary but insufficient response to the changed landscape.

In this century, scientific advancement, economic competitiveness, and national security are inextricably intertwined. And there are more S&T players along so many dimensions: nations, sectors, demographic and geographic backgrounds.

Now we need to build and educate together and improve our models and institutions, or design new ones, so that our S&T ecosystem, and especially the federal components, can move at the speed of science and innovation and deliver societal benefits from research that Americans actually need and want.

We have our work cut out for us.



I'd like us as a Board to think about how to improve our models and institutions. We have a wealth of expertise and I know you all have great ideas to contribute. Let me trigger a few thoughts.

First, and most obviously, we must finish the job on CHIPS & Science. The first thing we can do together as a science and policy community is to make a clear, concerted, and sustained push for following through on this priority.

Of course, the elephant in the room is money.

With the CHIPS part of *CHIPS & Science*, federal funding *and* industry investment came together and that encouraged further investment by state and local governments. It has fostered new partnerships and collaboration among the federal government, industry, and academia.

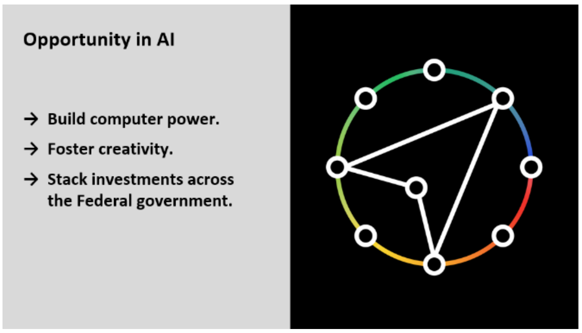
This shows us what's possible and is a potential model for future initiatives.

Through coordinated action, public and private money can be combined to compete globally and secure US leadership in priority areas like semiconductors, AI, quantum, and post-genomic biology.

But while we have this promising model for instantiating a national strategy for an S&T priority, critical components have stalled. Here, we know that all too well. The failure to fund the elements related to developing STEM talent and the "Science" part of *CHIPS & Science* are serious impediments.

The current surge of private sector R&D in the U.S. will falter if our nation continues underinvesting at the federal level in both ideas and talent. If we are to be successful, we need *all* of *CHIPS & Science*, especially if we hope to replicate its model for other critical technology fields.

Because in this changed landscape, if we want to do something big, we've got to do it *together*.



The next major opportunity that demands a cross-sectoral approach is AI.

It's a technology that's going to affect all fields and intersect with every part of the economy, including science and how science is done. In that context, let me tell you why it is an incomplete story to say that what the federal government can do constitutes an "AI strategy."

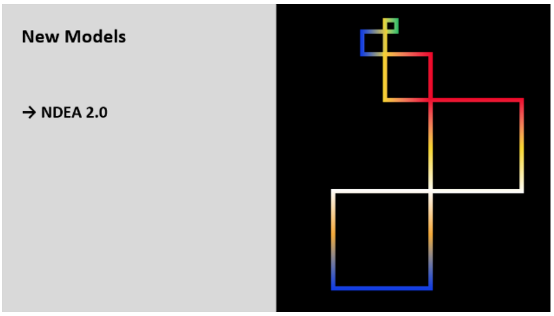
Here's the reality: for AI, the only part of the ecosystem that's healthy, with the infrastructure and talent required to push limits, is the business sector. Even our very best universities have a structural problem: they can't reproduce the state-of-the-art results that industry creates or truly push the frontiers. They simply don't have the necessary compute power, among other things.

The same is true of government scientists. Those of us in industry worry that hiring the best talent out of academia will leave no one left to teach the next generation. If we were talking about the role of financial institutions, we'd say that we have a market failure.

This moment calls for creativity. We have the potential for investments from a variety of sources: an AI Act, the National Artificial Intelligence Research Resource, state action, and a great deal of activity in business. But we don't know how to connect these pieces and coordinate them to achieve common goals and ensure that we're safeguarding the public interest.

Unless we have an equivalent of what's being done with semiconductors, with stacked investments and clearly defined strategies, we're going to have a serious problem with adverse impacts on our economic competitiveness, our national security, and perhaps even the very fabric of our society.

And while federal government leadership is indispensable, the federal government cannot solve this problem alone.

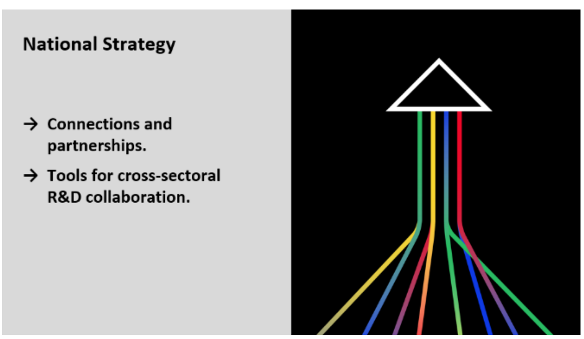


Next, we must inspire our fellow Americans with the promise of S&T and translate that inspiration into participation by attracting and retaining domestic talent from every demographic and every corner of the country and connecting them via vibrant STEM education and fulfilling careers.

As our previous Chair Dan Reed testified before Congress this past spring, "that it's time - in fact well past time - for a National Defense Education Act 2.0 that would inspire and enable a new generation to participate in S&T."

The return on that investment would be huge for both the country and for individuals.

And it is both ethical and prudent to ensure we are not leaving large fractions of our population or regions of the country behind.



The future success of our R&D ecosystem will also depend on our ability to quickly coordinate and align our S&T activities across sectors and keep pace with the speed of scientific and technological advances.

We need to design and *execute* a cross-sectoral national S&T strategy.

Our decentralized system facilitates creativity and resilience but also has inefficiencies. The radical changes in the R&D landscape call for a new approach to federal stewardship of our S&T ecosystem that maintains the benefits of our distributed system while still positioning our nation for success. This may require not just improving existing institutions but building new ones.

Furthermore, we need to develop the tools *within* each federal agency that will enable this cross-sectoral R&D collaboration.

An example is NSF's directorate for Technology, Innovation, and Partnerships, or TIP. As we all know, this is NSF's first new directorate in 30 years. It aims to drive regional innovation, bring new participants to the table, and sustain connections across sectors. This is the kind of new model that agencies need to be able to create and use, to leverage federal investments to complement activities and research in the private sector.

This is part of the "and Science" that we need to follow through on because we're going to need the resources and commitment to scale and land it.

This is a call to action.

There are many open questions that we need to explore.

Will evolving our existing institutions be enough or should we create new structures and institutions to better enable cross-sectoral collaboration and activities?

How should we approach international engagements? What is the G7 or G20 of technology? Do we need a NATO for S&T?

Should we lean into continued but selective collaboration with China on basic and open science to stay true to our values about open scientific inquiry and to avoid technological surprise?

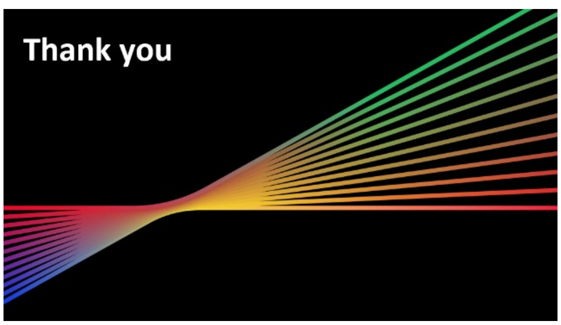
How can we mobilize all our country's assets to address our persistent challenges in STEM education?

How can we use the 75th anniversary as an opportunity to engage with our stakeholders to think together about how to evolve NSF to be even more successful in its next 75 years?

I’ll conclude with an invitation to the task ahead.

There’s no less opportunity now than there was at the beginning of this journey 75 years ago. We’re starting to learn and figure out the ingredients for success in an era of connected horizons. We must invent the right models and the right institutions. We must try new experiments and build and scale for success.

With the Board, I’d like to start thinking about how we can educate together and build together across sectors. I have some nascent ideas and am looking forward to working with you to develop a potential policy piece. If this is something you’re interested in working on, let us know!



I’ll leave you with these final thoughts:

The changed landscape is not a *bad* picture. It’s a *different* picture, a *new* picture.

It’s a landscape that is full of promise if we can figure out how to capitalize on its advantages and strengths.

It’s not a moment to wish to turn back the clock. It’s a moment to keep our eyes on the future.

Let’s work together, connecting across not a single frontier but many horizons, to deliver on the promise of S&T for our nation and for humanity. This is something that will take all of us, finding new ways to educate and build together. Let’s take the opportunities we have today to surface ideas with our distinguished panel, in our committees, and in our discussions with NSF's leaders. Even as we celebrate NSF's 75th anniversary, let's lay the groundwork for the next 75.

Thank you.